STATUS REPORT
ON
SEARCH ON THE ELECTRICAL PROPERTI
OF
SEMI-CONDUCTORS

Project No NR 072 160
N6 ori 07138 Report No 4

ELECTRICAL ENGINEERING RESEARCH LABORATORY
ENGINEERING EXPERIMENT STATION
UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

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ON
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OF
SEMI-CONDUCTORS

Project No. NR 072 160
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Date:
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Period:

31 May 1953

to

31 August 1953

Approved by:

T. A. Murrell
Associate Professor

ELECTRICAL ENGINEERING RESEARCH LABORATORY
ENGINEERING EXPERIMENT STATION
UNIVERSITY OF ILLINOIS
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1. INTRODUCTION

1.1 Purpose

This is the fourth status report on the lead telluride investigation being carried out under ONR sponsorship at the University of Illinois. This report covers the period 1 June 1953 to 31 August 1953, and marks the shift from four-month to three-month reporting intervals. The purpose of the investigation is to study the semi-conducting properties of PbTe single crystals of various compositions. A second crystal has been produced and a start made on electrical measurements. Zone purification methods are being investigated.

1.2 Personnel

Because of a special series of courses on semi-conductors and transistors offered at the University of Illinois during the summer session, Mr. Sirrine and Prof. Murrell were able to devote only one month to research during the period of this report. Beginning with the fall semester, both will spend approximately half time on the project. Arrangements have been made to add a second graduate student, Mr. Oleg Golubjatnikov, on a half-time appointment, and an undergraduate, Mr. Richard T. Pfluger, on an hourly basis. Both are expected to join the project in September.

2. EQUIPMENT AND FACILITIES

The problem of zone purification is being studied to determine equipment requirements. Induction heating would probably be the most convenient method, but in view of the magnitude of the investment, an attempt is being made to design a heater using electrical windings. Several configurations have attained the proper temperature with a good gradient, but the windings rapidly became brittle and burned out. The work is continuing.

3 SUMMARY OF ACTIVITIES

3.1 Mixing Process

A new apparatus for mixing has been constructed of Vycor, replacing the one of Pyrex, to permit more prolonged heating of the lead in hydrogen prior to mixing with the tellurium. One successful run has been carried out, with an apparent improvement in the removal of oxides.

3.2 Crystal Growing

A second single crystal has been grown, somewhat smaller than the first, using the improved mixing procedure referred to above. The excess lead which was present was excluded during the growth process, appearing as a cap of free lead at the top of the crystal. The crystal was then cleaved into slices about 1/8" thick, and a hot probe was used to measure the thermoelectric effect. The slice nearest the top turned out to be n-type, those lower down, p-type. One slice tested n-type on one face and p-type on the other, and thus contains a p-n junction. However, there is always some doubt about the interpretation of a room temperature thermoelectric measurement, and the junction may be too gradual to be useful. Further investigations will be made.

3.4 Electrical Measurements

Rectangular samples suitable for Hall effect and resistivity measurements have been cleaved from both crystals. The ends were etched in a solution of 30% H_2O_2, 0.02 N with respect to NaOH, and nickel plated using a standard plating solution. Small diameter tinned wires were then soldered to the nickel plated areas to serve as current leads. To date the conductivity of only one sample (n-type) has been measured over a small range of temperature. The results are shown in Fig. 1, plotted as log resistivity vs. reciprocal of the absolute temperature. Without the accompanying Hall data no exact conclusions can be drawn from the curve. There is no reason to expect a straight line aside from the fact that the temperature range is so limited. Future measurements will be carried out to greater ranges in both directions.

A rough estimate of the concentration of impurities may be made by using the fact that mobility is much less affected by changes in impurities than is conductivity. Using a value of 2000 cm^2/volt-sec for the mobility at room temperature[1], a value of 1.2×10^{17} carriers per cm^3 is obtained. It is also assumed that the concentration of electrons is considerably greater than that of holes, which is probably not well obeyed. The concentration of carriers would not be expected to change very much with temperature for such a low purity sample, so the chief contribution to the change in resistivity arises from variations in the mobility.

(1) E. H. Putley. *Proc. Phys. Soc. (London) B, 65,* 388 (1952)

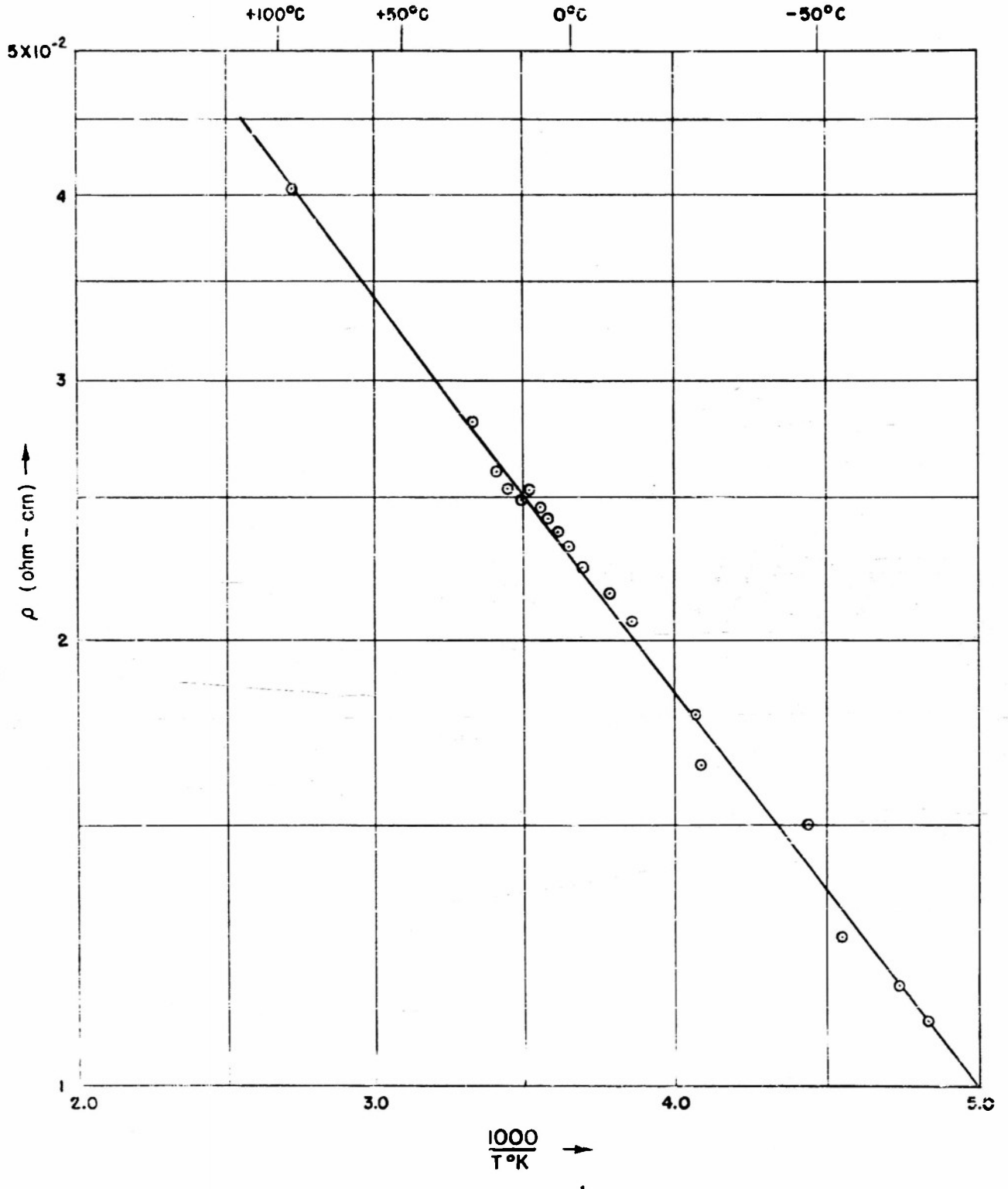

FIGURE 1 RESISTIVITY VS. $\frac{1}{T}$ FOR N-TYPE PbTe

4 PLANS FOR THE NEXT INTERVAL

There is little to add to the discussion of plans in the previous report. Zone purification is being studied and there seems to be some hope of being able to use electrical heater windings for this purpose. The purchase of an induction heater is being considered for Ge and Si crystal growing on Contract N6-ori-71 Task 40, with whom we are in close association. If one is obtained, it would be possible to use it from time to time for zone treatment of the PbTe.

Further consideration of the substitutional alloying method leads to the conclusion that In shows promise as an alloying agency Some attempts to produce a fused junction will be made.